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DEACTIVATION ROLLER HYDRAULIC VALVE LIFTER

RELATIONSHIP TO OTHER APPLICATIONS

This application is a Continuation of pending U.S. Patent Application Serial Number 10/341,155, filed January 13, 2003, which was filed as a Continuation of U.S. Patent No. 6,513,470, filed October 20, 2000, which was filed as a Continuation-in-Part of U.S. Patent Application Serial No. 09/607,071, filed June 29, 2000, which claims the benefit of U.S Provisional Patent Application Serial No. 60/141,985, filed July 1, 1999.

TECHNICAL FIELD

The present invention relates to hydraulic valve lifters for use with internal combustion engines, and, more particularly, to a lifter-based device which accomplishes cylinder deactivation in push-rod engines.

BACKGROUND OF THE INVENTION

Automobile emissions are said to be the largest contributor to pollution in numerous cities across the country. Automobiles emit hydrocarbons, nitrogen oxides, carbon monoxide and carbon dioxide as a result of the combustion process. The Clean Air Act of 1970 and the 1990 Clean Air Act set national

goals of clean and healthy air for all and established responsibilities for industry to reduce emissions from vehicles and other pollution sources. Standards set by the 1990 law limit automobile emissions to 0.25 grams per mile (gpm) non-methane hydrocarbons and 0.4 gpm nitrogen oxides. The standards are predicted to be further reduced by half in the year 2004. It is expected that automobiles will continue to be powered by internal combustion engines for decades to come. As the world population continues to grow, and standards of living continue to rise, there will be an even greater demand for automobiles. This demand is predicted to be especially great in developing countries. The increasing number of automobiles is likely to cause a proportionate increase in pollution. The major challenge facing automobile manufacturers is to reduce undesirable and harmful emissions by improving fuel economy, thereby assuring the increased number of automobiles has a minimal impact on the environment. One method by which automobile manufacturers have attempted to improve fuel economy and reduce undesirable emissions is cylinder deactivation.

Cylinder deactivation is the deactivation of the intake and/or exhaust valves of a cylinder or cylinders during at least a portion of the combustion process, and is a proven method by which fuel economy can be improved. In effect, cylinder deactivation reduces the number of engine cylinders within which the combustion process is taking place. With fewer cylinders performing combustion, fuel efficiency is increased and the amount of pollutants emitted from the engine will be reduced. For example, in an eight-cylinder engine under

certain operating conditions, four of the eight cylinders can be deactivated. Thus, combustion would be taking place in only four, rather than in all eight, cylinders. Cylinder deactivation is effective, for example, during part-load conditions when full engine power is not required for smooth and efficient engine operation. In vehicles having large displacement push rod engines, studies have shown that cylinder deactivation can improve fuel economy by as much as fifteen percent.

The reliability and performance of the large displacement push rod engines was proven early in the history of the automobile. The basic designs of the large displacement push rod engines in use today have remained virtually unchanged for a period of over thirty years, due in part to the popularity of such engines, the reluctance of the consumer to accept changes in engines, and the tremendous cost in designing, tooling, and testing such engines. Conventional methods of achieving cylinder deactivation, however, are not particularly suited to large displacement push rod engines. These conventional methods typically require the addition of components which do not fit within the space occupied by existing valve train components. Thus, the conventional methods of achieving cylinder deactivation typically necessitate major design changes in such engines.

Therefore, what is needed in the art is a device which enables cylinder deactivation in large displacement push rod engines.

Furthermore, what is needed in the art is a device which enables cylinder deactivation in large displacement push rod engines and is designed to fit within

existing space occupied by conventional drive train components, thereby avoiding the need to redesign such engines.

Moreover, what is needed in the art is a device which enables cylinder deactivation in large displacement push rod engines without sacrificing the size of the hydraulic element.

SUMMARY OF THE INVENTION

The present invention provides a deactivation hydraulic valve lifter for use with push rod internal combustion engines. The lifter can be selectively deactivated such that a valve associated with the lifter is not operated, thereby selectively deactivating the engine cylinder.

The invention comprises, in one form thereof, a deactivation hydraulic valve lifter including an elongate lifter body having a substantially cylindrical inner wall. The inner wall defines at least one annular pin chamber therein. The lifter body has a lower end configured for engaging a cam of an engine. An elongate pin housing includes a substantially cylindrical pin housing wall and pin housing body. Preferably, the pin housing wall includes an inner surface and an outer surface. A radially directed pin bore extends through the pin housing bottom. The pin housing is concentrically disposed within the inner wall of the lifter body such that the outer surface of the pin housing wall is adjacent to at least a portion of the inner wall of the lifter body. Preferably, a plunger having a substantially cylindrical plunger wall with an inner surface and an outer surface is

concentrically disposed within the pin housing such that the outer surface of the plunger wall is adjacent to at least a portion of the inner surface of the pin housing wall. A deactivation pin assembly is disposed within the pin bore and includes two pin members. The pin members are biased radially outward relative to each other. A portion of each pin member is disposed within the annular pin chamber to thereby couple the lifter body to the pin housing. The pin members are configured for moving toward each other when the pin chamber is pressurized, thereby retracting the pin members from within the annular pin chamber and decoupling the lifter body from the pin housing.

An advantage of the present invention is that it is received within standard-sized engine bores which accommodate conventional hydraulic valve lifters.

Another advantage of the present invention is that the deactivation pin assembly includes two pin members, thereby increasing the rigidity, strength, and operating range of the deactivation hydraulic valve lifter.

Yet another advantage of the present invention is that no orientation of the pin housing relative to the lifter body is required.

A still further advantage of the present invention is that the pin housing is free to rotate relative to the lifter body, thereby evenly distributing wear on the annular pin chamber.

An even further advantage of the present invention is that an external lost motion spring permits the use of a larger sized hydraulic element and operation under higher engine oil pressure.

Lastly, an advantage of the present invention is that lash can be robustly and accurately set to compensate for manufacturing tolerances.

BRIEF DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features and advantages of this invention, and the manner of attaining them, will become apparent and be better understood by reference to the following description of one embodiment of the invention in conjunction with the accompanying drawings, wherein:

FIG. 1 is a partially sectioned, perspective view of one embodiment of the deactivation roller hydraulic valve lifter of the present invention;

FIG. 2A is an axial cross-sectional view of the lifter body of claim 1;

FIG. 2B is an axial cross-sectional view of the lifter body of claim 1 rotated by 90 degrees;

FIG 3 is an axial cross-sectional view of Fig. 1;

FIG 4 is a radial cross-sectional view of Fig. 3 taken along line 4-4;

FIG 5 is a perspective view of the pin members of Fig. 1; and

FIG 6 is an axial cross-sectional view of the pin housing, plunger assembly, and push rod seat of Fig. 1;

FIG. 7 is an axial cross-sectional view of the push rod seat of Fig. 1; and

FIG 8 is an axial cross-sectional view of an alternate configuration of the deactivation roller hydraulic valve lifter of the present invention.

Corresponding reference characters indicate corresponding parts throughout the several views. The exemplification set out herein illustrates one preferred embodiment of the invention, in one form, and such exemplification is not to be construed as limiting the scope of the invention in any manner.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and particularly to Fig. 1, there is shown one embodiment of a deactivation roller hydraulic valve lifter 10 of the present invention. Deactivation roller hydraulic valve lifter (DRHVL) 10 includes roller 12, lifter body 14, deactivation pin assembly 16, plunger assembly 18, pin housing 20, pushrod seat assembly 22, spring seat 23, lost motion spring 24, and spring tower 26. As will be more particularly described hereinafter, plunger assembly 18 is disposed concentrically within pin housing 20 which, in turn, is disposed concentrically within lifter body 14. Pushrod seat assembly 22 is disposed concentrically within pin housing 20 above plunger assembly 18. Roller 12 is associated with lifter body 14. Roller 12 rides on the cam of an internal combustion engine and is displaced vertically thereby. Roller 12 translates the rotary motion of the cam to vertical motion of lifter body 14. Deactivation pin assembly 16 normally engages lifter body 14, thereby transferring the vertical reciprocation of lifter body 14 to pin housing 20 and, in turn, to plunger assembly 18 and pushrod seat assembly 22. In this engaged position, the vertical reciprocation of DRHVL 10 opens and closes a valve of the internal combustion

engine. Deactivation pin assembly 16 disengages to decouple lifter body 14 from pin housing 20 and, in turn, decouples plunger assembly 18 and pin housing 20 from the vertical reciprocation of lifter body 14. Thus, when deactivation pin assembly 16 is in the disengaged position, only lifter body 14 undergoes vertical reciprocation.

Roller 12 is of conventional construction, having the shape of a hollow cylindrical member within which bearings 28 are disposed and retained. Roller 12 is disposed within a first end 15 of lifter body 14. Shaft 30 passes through roller 12 such that bearings 28 surround shaft 30, bearings 28 being disposed intermediate shaft 30 and the inside surface of roller 12. Shaft 30 is attached by, for example, staking to lifter body 14. Lifter body 14 includes on its outside surface anti-rotation flats (not shown) which are aligned with anti-rotation flats on an interior surface of a conventional anti-rotation guide (not shown) within which lifter body 14 of DRHVL 10 is inserted. This assembly is placed in the lifter bore of push-rod type engine 31. Roller 12 rides on the cam (not shown) of push-rod type engine 31. Roller 12 is constructed of, for example, hardened or hardenable steel or ceramic material.

Referring now to Figs. 2a and 2b, lifter body 14 is an elongate cylindrical member dimensioned to be received within the space occupied by a standard roller hydraulic valve lifter. For example, lifter body 14 has a diameter of approximately 0.842 inches. Lifter body 14 has central axis A and includes cylindrical wall 32 having an inner surface 34 and a top end 33. Inner surface 34

includes circumferential oil supply recess 34a. Diametrically opposed shaft orifices 35 and 36 are defined in cylindrical wall 32 and include rim portions 35a and 36a, respectively. Rim portions 35a and 36a have a diameter that is slightly greater than the diameter of shaft orifices 35 and 36, respectively. Shaft 30 passes through shaft orifice 35, extends diametrically through roller 12, and at least partially into shaft orifice 36. One end of shaft 30 is disposed in rim portion 35a and the other end of shaft 30 is disposed within rim portion 36a. The slightly larger diameter of rim portions 35a and 36a relative to shaft orifices 35 and 36 enables shaft 30 to be attached, such as, for example, by staking to lifter body 14. Cylindrical wall 32 defines roller pocket 37 intermediate shaft orifices 35 and 36, which receives roller 12.

Cylindrical wall 32 defines control port 38 and oil port 40. Inner surface 34 of cylindrical wall 32 defines annular pin chamber 42 therein. Preferably, annular pin chamber 42 is a contiguous chamber of a predetermined axial height, and extends around the entire circumference of inner surface 34 of cylindrical wall 32. Control port 38 is defined by one opening which extends through cylindrical wall 32, terminating at and opening into annular pin chamber 42. Thus, control port 38 provides a fluid passageway through cylindrical wall 32 and into annular pin chamber 42. Pressurized oil is injected through control port 38 into annular pin chamber 42 in order to retract deactivation pin assembly 16 from within annular pin chamber 42. Oil port 40 passes through cylindrical wall 32 and into oil supply recess 34a, thereby providing a passageway for lubricating oil to enter the

interior of lifter body 14. Lifter body 14 is constructed of, for example, hardened or hardenable steel.

As best shown in Figs. 3 and 4, deactivation pin assembly 16 includes two pin members 46, 48 interconnected by and biased radially outward relative to lifter body 14 by pin spring 50. As shown in Fig. 5, each of pin members 46, 48 are round pins having stepped flats 46a and 48a which are dimensioned to be received within annular pin chamber 42. As will be described with more particularity hereinafter, a small gap G is provided between flats 46a, 48a and the lower edge of annular pin chamber 42. Gap G provides for clearance between flats 46a and 48a and the lower edge of annular pin chamber 42, thereby allowing for free movement of pin members 46 and 48 into pin chamber 42. Each of pin members 46 and 48 include at one end pin faces 47 and 49, respectively, and define pin bores 52 and 54, respectively, at each opposite end. Each of pin bores 52 and 54 receive a corresponding end of pin spring 50. In its normal or default position, pin members 46 and 48 of deactivation pin assembly 16 are biased radially outward by pin spring 50 such that at least a portion of each pin member 46 and 48 is disposed within annular pin chamber 42 of lifter body 14. Preferably, pin faces 47 and 49 have a radius of curvature that corresponds to the curvature of inner surface 34 of cylindrical wall 32. Thus, line contact is provided between pin faces 47, 49 and the inner surface of pin chamber 42 upon initial engagement of pin members 46, 48 within pin chamber 42. Each of pin members 46, 48 include stop grooves 46b and 48b, respectively.

Stop grooves 46b, 48b extend a predetermined distance from the end of each pin member 46, 48 that is opposite pin faces 47, 49, respectively. Pin members 46 and 48 are constructed of, for example, hardened or hardenable steel. Pin spring 50 is a coil spring constructed of, for example, music wire.

Referring now to Fig. 6, preferably, plunger assembly 18 is disposed within pin housing 20 which, in turn, is disposed within lifter body 14. Plunger assembly 18 includes plunger 60, plunger ball 62, plunger spring 64 and ball retainer 66. Plunger 60 is a cup shaped member including a cylindrical side wall 68 and a plunger bottom 70, and is slidably disposed concentrically within pin housing 20. Plunger side wall 68, bottom 70, and pushrod seat assembly 22 conjunctively define low-pressure chamber 72. Plunger bottom 70 includes plunger orifice 74 and seat 76. Plunger orifice 74 is circular in shape, having a predetermined diameter, and is concentric with plunger cylindrical side wall 68. Seat 76 is a recessed area defined by plunger bottom 70. Plunger 60 is constructed of, for example, hardenable or hardened steel. Plunger ball 62 is movably disposed within ball retainer 66, which, in turn, is disposed within seat 76 adjacent plunger bottom 70. Plunger spring 64 is a coil spring and is disposed between pin housing 20 and plunger assembly 18. More particularly, plunger spring 64 is disposed between seat 76 of plunger bottom 70 and pin housing 20, pressing ball retainer 66 against seat 76 of plunger bottom 70. In that position, plunger ball 62 and ball retainer 66 conjunctively define a ball-type check valve. Plunger ball 62 is a spherical ball of a predetermined circumference

such that plunger ball 62 is movable within ball retainer 66 toward and away from plunger orifice 74, and seals plunger orifice 74 in a fluid tight manner. Plunger ball 62 is constructed of, for example, hardenable or hardened steel.

Pin housing 20 includes cylindrical side wall 80, having an inner surface 82, outer surface 83, and body portion 84. Body portion 84 includes an inside surface 86 and an outside surface 88. Inside surface 86 is in the form of a cylindrical indentation which is surrounded by ledge 92. Pin housing body portion 84 defines a cylindrical deactivation pin bore 94 radially therethrough. Deactivation pin assembly 16 is disposed within deactivation pin bore 94. Drain aperture 96 is also defined by body portion 84 and extends from deactivation pin bore 94 through to outer surface 88 of body portion 84. Body portion 84 further defines two stop pin apertures 98 therein. Stop pin apertures 98 are parallel relative to each other and perpendicular relative to deactivation pin bore 94. Stop pin apertures 98 extend through side wall 80 radially inward through body portion 84, intersecting with and terminating in deactivation pin bore 94. Inner surface 82 of side wall 80 defines a lower annular groove 104 proximate to and extending a predetermined distance above ledge 92. Inner surface 82 also defines an intermediate annular groove 106 and an upper annular groove 108. Pin housing 20 is free to rotate relative to lifter body 14, and thus is not rotationally constrained within lifter body 14. Pin housing 20 is constructed of, for example, hardenable or hardened steel.

High pressure chamber 100 is conjunctively defined by bottom inner surface 86 of pin housing 20, plunger bottom 70, and the portion of inner surface 82 of cylindrical side wall 80 disposed therebetween. Plunger orifice 74 provides a passageway for the flow of fluid, such as, for example, oil, between high pressure chamber 100 and low pressure chamber 72. The ball-type check valve formed by plunger ball 62 and ball retainer 66 selectively controls the ability of the fluid to flow through plunger orifice 74.

Referring now to Fig. 7, pushrod seat assembly 22 includes cylindrical plug body 110 having a bottom surface 112 with a circumferential seat ring 114. Opposite bottom surface 112 is a bowl shaped socket 118 surrounded by shelf 120. Pushrod seat assembly 22 is disposed concentrically within pin housing 20 such that bottom surface 112 is adjacent to the top of side wall 68 of plunger 60. Plug body 110 defines pushrod seat orifice 122, which is concentric with plug body 110 and extends axially from bottom surface 112 through to socket 118. Insert 124 is inserted, such as, for example, by pressing, into pushrod seat orifice 122. Insert 124 carries an insert orifice 126 having a very small diameter of, for example, about 0.1 to 0.4 mm. Insert 124 is disposed within pushrod seat orifice 122 such that pushrod seat orifice 122 and insert orifice 126 are concentric and in fluid communication with each other. Pushrod seat 22 and insert 124 are constructed of, for example, hardenable or hardened steel.

Spring seat 23, as best shown in Fig. 3, is a ring-shaped member, having collar 130, flange 132, and orifice 134. Collar 130 is disposed concentrically

within lifter body 14 and adjacent to upper end 78 (FIG.6) of side wall 80 of pin housing 20. Flange 132 extends radially from collar 130 such that flange 132 overlaps onto the top edge of cylindrical wall 32 of lifter body 14. The height of gap G is determined by the dimensions of spring seat 23. More particularly, the amount of length by which collar 130 extends axially into lifter body 14 determines the axial position of pin housing 20 relative to lifter body 14, thereby determining the height of gap G.

Lost motion spring 24, as best shown in Fig. 3, is a coil spring having one end 25a associated with spring seat 23 and the other end 25b associated with spring tower 26. Lost motion spring 24 has a predetermined installed load which is selected to prevent hydraulic element pump up due to oil pressure in high pressure chamber 100 and due to the force exerted by plunger spring 64. Lost motion spring 24 is constructed of, for example, hardenable or hardened steel.

Spring tower 26, as best shown in Fig. 3, is an elongate cylindrical member having an outer wall 140. A plurality of slots 142 are defined in outer wall 140. Tabs 144 are formed along lower end 141 of outer wall 140. A portion of outer wall 140 is concentrically disposed within pin housing 20, adjacent to inner surface 82 of side wall 80. Slots 142 enable spring tower 26 to be flexible enough to be pushed downward into pin housing 20 until each of tabs 144 are received within and snap into or engage upper annular groove 108 formed in side wall 80 of pin housing 20. Spring tower 26 defines at its top end tower flange 146, which is associated with the top end 25a of lost motion spring 26. The lower

end 141 of spring tower 26, disposed within pin housing 20, acts to limit the extended height of pushrod seat assembly 22.

Stop pins 148, as best shown in Fig. 4, are, for example, pressed into stop pin apertures 98, and extend a predetermined distance into deactivation pin bore 94 of pin housing 20. Stop pins 148 are configured for restricting the inward retraction of pin members 46 and 48 of deactivation pin assembly 16. A respective end of each stop pin 148 is disposed within a corresponding one of stop grooves 46b and 48b of pin members 46, 48, thereby preventing the undesirable condition of pin shuttle. Generally, pin shuttle occurs when a deactivation pin or pin member is radially displaced or pushed to one side or the other of a housing and is therefore unable to completely disengage from within an orifice or deactivation chamber. Further, stop pins 148 in conjunction with stop grooves 46b, 48b prevent excessive rotation of pin members 46, 48 relative to pin housing 20. Stop pins 148 are constructed of, for example, hardenable or hardened steel.

Spring tower 26 may be alternately configured, as shown in Fig. 8, to include a ring groove 150 and beveled edge 152 at lower end 141'. In this embodiment, a resiliently deformable retaining ring 154 is disposed within upper annular groove 108 of pin housing 20. In order to assemble DRHVL 10, spring tower 26 is pushed downward into pin housing 20. As spring tower 26 is inserted into pin housing 20 and pushed axially downward, beveled edge 152 of spring tower 26 contacts retaining ring 154 which is, in turn, displaced axially downward.

This downward displacement of retaining ring 154 continues until retaining ring 154 contacts the bottom of upper annular groove 108, which prevents further downward movement of retaining ring 154. As downward motion of spring tower 26 continues, beveled edge 152 then acts to expand the resiliently deformable retaining ring 154. Thus, retaining ring 154 is resiliently expanded by beveled ~~bottom~~ edge 152 as spring tower 26 is pushed downward into pin housing 20. The expanded retaining ring 154 slides over spring tower 26 as spring tower 26 is pushed further downward into pin housing 20. When ring groove 150 and retaining ring 154 are in axial alignment, retaining ring 154 snaps into ring groove 150. As downward pressure upon spring tower 26 is removed, the action of lost motion spring 24 exerts an upward force on spring tower 26 until retaining ring 154 contacts the top edge of upper annular groove 108. Thus, retaining ring 154 retains a portion of spring tower 26 within pin housing 20, and determines the axial position of spring tower 26 relative to pin housing 20. Spring tower 26 is constructed of, for example, hardenable or hardened steel.

In use, roller 12 is associated with and rides on a lobe of an engine cam (not shown) in a conventional manner. Shaft 30 is attached within shaft orifices 35, 36, such as, for example, by staking, to lifter body 14. Thus, as the engine cam rotates, roller 12 follows the profile of an associated cam lobe and shaft 30 translate the rotary motion of the cam and cam lobe to linear, or vertical, motion of lifter body 14. When deactivation pin assembly 16 is in its normal operating or default position, pin members 46 and 48 are biased radially outward by pin spring

50. In this default position, pin members 46 and 48 extend radially outward from within deactivation pin bore 94 and at least partially into diametrically opposed locations within annular pin chamber 42. Deactivation pin assembly 16 is configured such that pin members 46 and 48 are biased radially outward to engage annular pin chamber 42 at diametrically opposed points. Annular pin chamber 42 is filled with fluid at all times during use, the fluid being at a low pressure when deactivation pin assembly 16 is in the normal or default position.

The use of two pin members results in a substantially rigid, strong, and durable assembly which can be used at higher engine speeds, or at higher engine revolutions per minute, than an assembly having one pin or non-diametrically opposed pins. The configuration of pin members 46 and 48 as round pin members with stepped flats 46a, 48a, respectively, increases the strength of the pin members and lowers the contact stress at the interface of pin members 46 and 48 and annular pin chamber 42. Annular pin chamber 42 is configured as a contiguous circumferential pin chamber. Thus, fixing the orientation of pin housing 20 relative to lifter body 14 is not necessary in order to ensure pin members 46 and 48 will be radially aligned with contiguous annular pin chamber 42. Pin members 46 and 48 rotate with pin housing 20 and will therefore randomly engage annular pin chamber 42 at various points along the circumference of lifter body 14. Thus, the rotation of pin housing 20 relative to lifter body 14 distributes the wear incurred by annular pin chamber 42 being repeatedly engaged and disengaged by pin members 46 and 48.

With pin members 46 and 48 engaged within annular pin chamber 42 of lifter body 14, vertical movement of lifter body 14 will result in vertical movement of pin housing 20, plunger assembly 18, and pushrod seat assembly 22. Thus, lifter body 14, plunger assembly 18, pin housing 20, and pushrod seat assembly 22 are reciprocated as substantially one body when deactivation pin assembly 16 is in its default position. With pin members 46 and 48 thus engaged, a push rod (not shown) seated in pushrod seat assembly 22 will likewise undergo reciprocal vertical motion. Through valve train linkage (not shown) the reciprocal motion of a push rod associated with pushrod seat assembly 22 will act to open and close a corresponding valve (not shown) of engine 31. Fluid, such as, for example oil or hydraulic fluid, at a relatively low pressure fills annular pin chamber 42 while pin members 46, 48 are engaged within annular pin chamber 42.

Deactivation pin assembly 16 is taken out of its default position and placed into a deactivated state by the injection of a pressurized fluid, such as, for example oil or hydraulic fluid, through control port 38. The injection of the pressurized fluid is selectively controlled by, for example, a control valve (not shown) or other suitable flow control device. The pressurized fluid is injected through control port 38 and into annular pin chamber 42 at a relatively high pressure to disengage the pin members 46, 48 from within annular pin chamber 42. Close tolerances between side wall 80 of pin housing 20 and inner surface 34 of cylindrical wall 32 of lifter body 14 act to retain the pressurized fluid within annular pin chamber 42, thus providing a chamber within which the pressurized

fluid flows. The pressurized fluid fills annular pin chamber 42 and exerts pressure on pin faces 47, 49. The pressure forces pin members 46 and 48 radially inward, thereby compressing pin spring 50. Pin members 46 and 48 are thus retracted from within annular pin chamber 42 and into deactivation pin bore 94. The radially-inward movement of pin members 46 and 48 is limited by stop pins 148 which ride within stop grooves 46b, 48b.

Pin members 46 and 48 are configured with pin faces 47, 49 having a radius of curvature which matches the radius of curvature of inner surface 34, thereby providing a large active surface area against which the pressurized oil injected into annular pin chamber 42 acts to retract pin members 46 and 48 from within annular pin chamber 42. Pin members 46 and 48 are sized to be in close tolerance with deactivation pin bore 94. However, some of the pressurized fluid injected into annular pin chamber 42 may push into the area of deactivation pin bore 94 between pin members 46 and 48. If the area of deactivation pin bore 94 between pin members 46 and 48 were to fill with fluid, retraction of pin members 46 and 48 would become virtually impossible and a lock-up condition can result. Drain aperture 96 in pin housing 20 allows any of the fluid injected into annular pin chamber 42 which leaks into deactivation pin bore 94 to drain from within pin bore 94, thereby preventing a lock-up condition of pin members 46 and 48. Further, drain aperture 96 is preferably oriented in the direction of reciprocation of DRHVL 10 to take advantage of the reciprocation of DRHVL 10 to promote the

drainage of fluid therethrough and, thereby, the removal of any fluid which has penetrated into deactivation pin bore 94.

With pin members 46 and 48 retracted from annular pin chamber 42, the vertical displacement of lifter body 14 through the operation of roller 12 is no longer transferred through pin members 46 and 48 to pin housing 20. Thus, pin housing 20, plunger assembly 18 and pushrod seat assembly 22 no longer move in conjunction with lifter body 14 when deactivation pin assembly 16 is in its deactivated state. Only lifter body 14 will be vertically displaced by the operation of the cam. Therefore, a push rod (not shown) seated in pushrod seat assembly 22 will not undergo reciprocal vertical motion, and will not operate its corresponding valve.

In the deactivated state, as lifter body 14 is vertically displaced by the engine cam lobe, lost motion spring 24 is compressed. As the cam lobe returns to its lowest lift profile, lost motion spring 24 expands and exerts, through spring seat 23, a downward force on lifter body 14 until flange 132 and collar 130 simultaneously contact lifter body 14 and pin housing 20, respectively. Any lift loss that occurs due to leakdown is recovered through the expanding action of plunger spring 64. Thus, the lash remaining in DRHVL 10 is limited to the gap G which is precisely set through the dimensions of spring seat 23. Excessive lash will accelerate wear of valve train components. Thus, where excessive lash exists, the interfacing components are pounded together as they are reciprocated by the cam. The pounding significantly increases wear and tear of the

components, and possibly premature lifter or valve train failure. As will be described in more detail hereinafter, spring seat 23 sets an appropriate amount of lash, thereby preventing excessive wear and premature valve train failure. The dimensions of spring seat 23 are precisely controlled during manufacture. Thus, gap G and the amount of lash incorporated into DRHVL 10 are precisely controlled.

Lost motion spring 24 prevents separation between DRHVL 10 and the engine cam in the deactivated or disengaged state. Further, lost motion spring 24 resists the expansion of DRHVL 10 when the cam is at its lowest lift profile position. The tendency of DRHVL 10 to expand is due to the force exerted by plunger spring 64 and oil pressure within high pressure chamber 100 acting upon plunger 60. These forces tend to displace pin housing 20 downward toward roller 12, thereby reducing gap G. Thus, the oil pressure within high pressure chamber 100 and the force exerted by plunger spring 64 will expand, or pump-up, DRHVL 10 by displacing pin housing 20 downward toward roller 12. Spring tower 26 is firmly engaged with pin housing 20, and thus any downward movement of or force upon pin housing 20 will be transferred to spring tower 26. Thus, a compressive force, or a force in a direction toward roller 12, is exerted upon lost motion spring 24 via the downward force or movement of pin housing 20 which is transferred to spring tower 26. The pre-load or installed load of lost motion spring 24 is selected to resist the tendency of DRHVL 10 to pump-up or expand. If expansion is not resisted or limited by the installed load of lost motion

spring 24, gap G will be reduced as pin housing 20 is displaced downward relative to pin chamber 42. Such unrestrained expansion and downward displacement of pin housing 20 may potentially adversely affect the ability of locking pin members 46, 48 to engage within pin chamber 42. If lost motion spring 24 is inadequately sized, gap G could be reduced an amount sufficient to prohibit the engagement of locking pins 46, 48 within pin chamber 42. Thus, lost motion spring 24 must be selected to resist the compressive forces exerted thereon due to the hydraulic element, operating oil pressure, and plunger spring.

Disposing lost motion spring 24 above lifter body 14, but within the plan envelope of DRHVL 10, provides increased space in which a larger lost motion spring 24 can be accommodated, which, in turn, enables the use in DRHVL 10 of a larger hydraulic element, higher operating oil pressure, and stronger plunger spring. Further, disposing lost motion spring 24 within the plan envelope of DRHVL 10 permits the insertion of DRHVL 10 into a standard-sized lifter anti-rotation guide. Spring tower 26 is, in effect, a reduced-diameter extension of pin housing 20. The diameter of spring tower 26 is a predetermined amount less than the diameter of pin housing 20 such that lost motion spring 24 can be of sufficient size and yet remain within the plan envelope of lifter body 14. Thus, spring tower 26 enables lost motion spring 24 to be appropriately sized and remain within the plan envelope of DRHVL 10.

Spring seat 23 is disposed intermediate lifter body 14 and lost motion spring 24 such that flange portion 132 of spring seat 23 is disposed adjacent lost

motion spring 24, and such that a first end 131 of collar portion 130 is disposed adjacent upper end 78 of pin housing 20. Spring seat 23 determines the relative positions of lifter body 14 and pin housing 20. More particularly, the axial dimension L, or length, of collar 130 determines the relative axial positions of lifter body 14 and pin housing 20. As shown in Fig. 3, gap G exists between the bottom of annular pin chamber 42 and the bottom of pin faces 47, 49. By changing the axial dimension of collar 130 gap G can be precisely manipulated. For example, lengthening collar 130 places pin housing 20 axially lower relative to lifter body 14 thereby decreasing the height of gap G. By adjusting the axial dimension of collar 130, variations in manufacturing tolerances and variations in the dimensions of the component parts of DRHVL 10 can be accurately compensated for while a tight tolerance on gap G is accurately maintained. Flexibility in manufacture and assembly is accomplished by manufacturing a number of spring seats 23 having collars 130 of various predetermined axial dimensions. A particular spring seat 23 would be selected based upon the axial dimension of collar 130 in order to produce a DRHVL 10 having an appropriately-sized gap G.

In the embodiment shown, lifter body 14 is sized to be received within a standard-sized anti-rotation guide or within a standard-sized lifter bore of a push-rod type internal combustion engine. However, it is to be understood that lifter body 14 may be alternately configured to have a greater or smaller size and/or

diameter and therefore be received within variously sized lifter bores and/or anti-rotation guides.

In the embodiment shown, annular pin chamber 42 is disclosed as being configured as a contiguous annular pin chamber. However, it is to be understood that annular pin chamber 42 may be alternately configured, such as, for example, as two or more non-contiguous annular chambers configured to receive a corresponding one of deactivation pin members 46 and 48. In this configuration, each annular pin chamber includes a corresponding control port through which the pressurized fluid is injected to retract a respective pin member from within the corresponding annular pin chamber.

In the embodiment shown, pin members 46 and 48 are disclosed as round pin members having flats 46a, 48a, respectively. However, it is to be understood that pin members 46 and 48 may be alternately configured, such as, for example, square or oval pin members having respective flats, or may be configured without flats, and be received within a correspondingly configured pin chamber.

In the embodiment shown, plunger ball 62 and ball retainer 66 conjunctively define a ball-type check valve. However, it is to be understood that DRHVL 10 may be alternately configured with, such as, for example, a plate-type check valve or any other suitable valve.

In the embodiment shown, deactivation pin assembly 16 includes two pin members 46, 48. However, it is to be understood that deactivation pin assembly 16 may include a single pin member or any desired number of pin members.

In the embodiment shown, stop pins 148 are disposed within a respective one of stop pin apertures 98 and extend radially inward to intersect with one side wall of deactivation pin bore 94. However, it is to be understood that stop pin apertures 98 may extend radially inward from locations on opposite sides of pin housing 20 and intersect with opposite side walls of deactivation pin bore 94.

In the embodiment shown, insert 124 is inserted by, for example, pressing into pushrod seat orifice 122. However, it is to be understood that insert 124 may be alternately configured, such as, for example, otherwise attached to or formed integrally with push rod seat 22.

While this invention has been described as having a preferred design, the present invention can be further modified within the spirit and scope of this disclosure. This application is therefore intended to cover any variations, uses, or adaptations of the present invention using the general principles disclosed herein. Further, this application is intended to cover such departures from the present disclosure as come within the known or customary practice in the art to which this invention pertains and which fall within the limits of the appended claims.